(*d*) Altimeter reading, expressed as height above sea level or above some specified point.

(*e*) The barometric pressure at which the altimeter would read zero altitude; place and time of take-off; temperature at surface at time of take-off.

(*f*) Temperature of the free air, read from a strut thermometer, at point of observation of phenomenon.

(*g*) General weather conditions at time of observation, including: Cloudiness—amount, kind, and heights of bases and tops of various cloud formations, if determined; precipitation—kind, intensity, greatest and lowest heights at which observable.

Some observations which are of assistance in attaining the first objective, viz, the location of surfaces of discontinuity and fronts, follow:

1. *Discontinuities in atmospheric turbidity, i.e., surfaces across which marked changes in turbidity are observable.*—(*a*) Haze layers; (*b*) dust layers; (*c*) tops and bases of stratiform clouds; (*d*) top of fog, etc.; giving in each case the cause of the turbidity, its thickness, horizontal extent, visibility, and measure of turbidity expressed preferably in some such scale of opalescent turbidity [1] as Bergeron has given in his well-known work, Über die Dreidimensional Verknüpfende Wetteranalyse, I, Geofysiske Publikasjoner, vol. V, Oslo, 1930.

2. *Thermal discontinuities.*—The airplane should carry a strut thermometer to detect such discontinuities. Due to various difficulties only inversions of temperature (i.e. increase of temperature with height) are easily detectable by means of a strut thermometer. Fronts also may be easily detectable thereby.

3. *Humidity discontinuities.*—Commercial airplanes usually are not equipped to measure relative humidity.

4. *Wind discontinuities.*—Marked shifts in wind direction, and rapid changes in speed with change in height or change in horizontal position are observable from mechanical effects on the flight of the airplane or from changes in the drift of the ship when the ground is visible. Squalls and wind-shift lines such as are encountered near cold fronts and in connection with thunderstorms, come under this heading.

As for the second objective mentioned above, there may be observed:

1. *Bumpiness.*—Bumpiness may be reported on a scale of 0–5, such as was given by W. H. Pick and G. A. Bull in Great Britain Meteorological Office Professional Notes No. 46, "A Note on Bumpiness at Cranwell, Lincolnshire," 1927; 0, no bumps; 1, slight bumps; 2, occasional bumps; 3, bumpy; 4, very bumpy; 5, exceptionally bumpy. Horizontal extent, nature of the terrain and accompanying phenomena, if noticeable, should also be given.

2. *Marked upward and downward large scale currents.*—These are most pronounced in spring and summer and usually in connection with cumulus and cumulo-nimbus clouds (thunderheads). Also with the squall-line attending cold fronts. Such currents are detectable by rapid vertical cloud motions and by differences in climbing or gliding speeds from the normal for the given flying conditions.

The third objective given above applies to miscellaneous phenomena, e.g.:

1. *Icing of airplane.*—Ice which accumulates on airplanes should be classified as (*a*) hard ice; (*b*) rime; (*c*) frost. Hard ice is essentially the same as glaze; however, it may be either clear or opaque (whitish). The thickness, physical appearance, place of formation, temperature of air, visibility in cloud (or rain) where formation occurred, rapidity of formation, etc., should also be given.

2. *Development of clouds.*—The aviator can frequently observe details in regard to the growth or disappearance of clouds not easily obtainable from ground observations. Such information may possibly be of value in the final analysis of what processes actually cause condensation of water vapor into clouds and subsequent precipitation.

In conclusion, it would appear feasible to prepare printed forms on which commercial pilots could indicate the pertinent phenomena observed during flights, and to develop a system whereby the pilot would turn in these reports to local weather observers at airports who would then forward them to the proper headquarters where studies would be made of the accumulated data. Such a cooperative effort might conceivably be of inestimable value in the long run to both parties concerned by virtue of the enhancement of our knowledge of the atmosphere and the improvement in forecasts.

The synopsis of weather analysis given earlier in the paper represents the consensus of opinion of officials at the Central Office of the Weather Bureau.

[1] The purpose of determining the opalescent turbidity is to obtain an approximate measure of the amount and fineness of the suspended solid material in the atmosphere which because it settles out so slowly is a semiconservative characteristic of air masses in general. A measure of the opalescent turbidity is, roughly speaking, a measure of the light-scattering power of the exceedingly fine solid particles which are suspended in the atmosphere. This measure is approximately inversely proportional to the visibility, provided that the observations of the latter are made so as to be independent of the distance, color, brightness, and albedo of the object viewed; the position of the sun with respect to the line of sight; the cloudiness; the color, brightness, and albedo of the sky and background, etc. To attain this end in a practical manner, Bergeron has laid down rules for selecting suitable objects, with instructions for making observations of visibility so that one may thus obtain a measure (approximate) inversely proportional to the opalescent turbidity. In this scheme, distant mountains and elevated objects are considered most suitable, provided that in making the scale of visibility the respective objects subtend equal angles at the eye of the observer no matter what their distance. The objects should not extend too high if it is desired to measure the horizontal visibility. The objects *must* be dark, preferably black. White objects, water, and brightly colored structures are precluded. Objects should not be viewed toward the sun, but preferably at right angles to the line from observer to sun, and not in twilight. Also, not under low thick clouds or fog, especially if the sky is largely clear. The nature and color of the objects so viewed, the relative positions of the sun, observer, object, and cloudiness, whether the object was shaded from the sun and sky largely clouded over, whether the object was illuminated and the sky largely clear, or whether other conditions prevailed in this respect, clarity of the details and contour of the object viewed, etc., should be stated with each observation; also any coloration observed due to the turbidity itself. (See also H. Koschmieder—Theorie der horizontalen Sichtweite, Beiträge zur Physik der freien Atmosphäre, Band XII, 1925, pp. 33–55, and 171–181.)

A STATISTICAL ANALYSIS OF FOGS AT GREENSBORO, N.C., AIRPORT

By JOHN C, SCHOLL

[Angier, N.C., May 1934]

During the 4-year period, August 1929 to July 1933, inclusive, fog occurred at the Greensboro Airport 381 times. Of this number 4 began as dense and ended as light, 1 was dense from start to finish, 116 began as light but were dense some time, while the remaining 260 were light all the time. The average number per month of light and dense fogs for this period was 7.9 and 2.5, respectively.

Each of these 381 cases was, of course, the result of either general or local meteorological changes. The general conditions and changes favorable to fog are well known. However, many of these fogs unquestionably occurred as a result of purely local changes, some of which were probably very slight and seemingly insignificant. Consequently the results of this study are not entirely representative of the conditions which exist in any locality other than the Greensboro Airport.

Figure 1 substantiates the general opinion that both light and dense fogs are more prevalent in the winter months. It is believed that if data were available for a sufficient number of years to produce acceptable monthly averages, the rise in line B for May would be ironed out. The same might be true for the small number of dense fogs in June.

Perhaps the most striking feature of figure 1 is the evidence of the appearance of radiation fogs during the usual months of their chief occurrence. In late summer and early autumn when this type of fog predominates it is noted that comparatively few fogs are heavy. Hence it appears that a relatively large number of frontal (a great portion of which occurred in the winter months), but comparatively few radiational, fogs became dense.

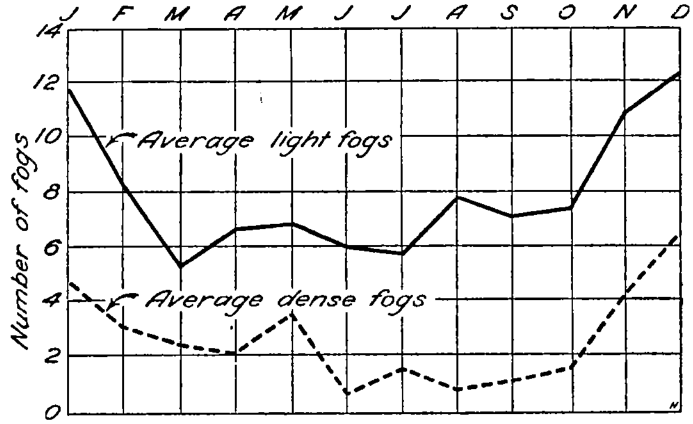

FIGURE 1.

One hundred and twenty of the one hundred and twenty-one dense fogs were at some time light and therefore are included in line A. Consequently line A actually shows all fogs, except one, that occurred during the period in question. Line B shows the fogs that some time were dense.

BAROMETER

The barometric change during the existence of each of the 381 fogs, and similar data for the 2-hour period preceding each, were obtained. Diurnal variations were eliminated before the data were tabulated. The mean average hourly barometer change during the fogs was +0.0001 inch, and the mean average hourly change for the 2 hours preceding them −0.0010 inch. Through most of these fogs the barometer remained practically stationary, but for the 2 hours preceding them it generally fell slightly.

Figure 2 shows the deviations of the monthly station barometer averages from their mean.

Some relationship apparently exists between graphs 2 and 3. Line A (fig. 3) shows that in the months in which the station barometer is above the average the barometer change during fogs is below the average and vice versa, except in cases of March and September; and it is interesting that these are the more or less accepted dividing lines between summer and winter.

Line B (fig. 3) is somewhat similar to A, the chief difference being that the maximum fall occurred in March whereas this fall occurred in December in case of A. Then, too, January offers an additional exception in the case of B, in that the fall for this month is slightly below the mean. It is significant that in A and B the January fall is slight compared to the months that immediately precede and follow.

The tendency of A and B to fall in the winter months when frontal fogs predominate is believed to exist mostly because of the following two reasons:

First, HIGHS often during these months "park" for a considerable time along the Atlantic Seaboard, usually centered around Maryland or a little farther north. When this condition is present damp northeast winds are blown in for several days. This set-up quite naturally

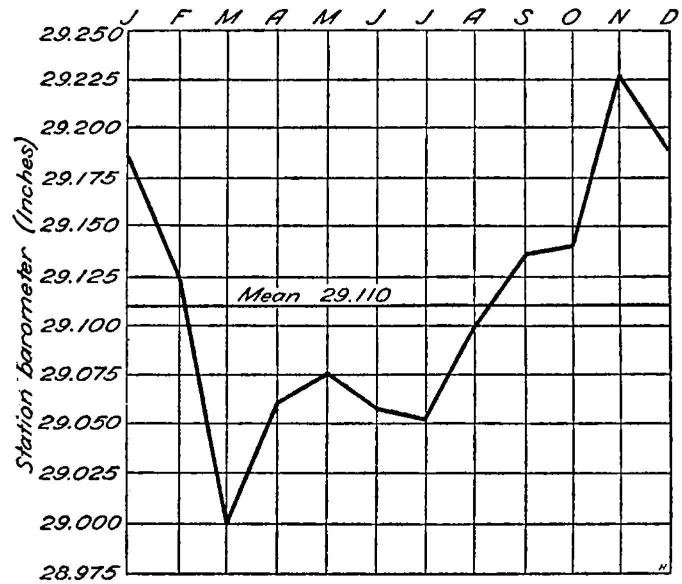

FIGURE 2.

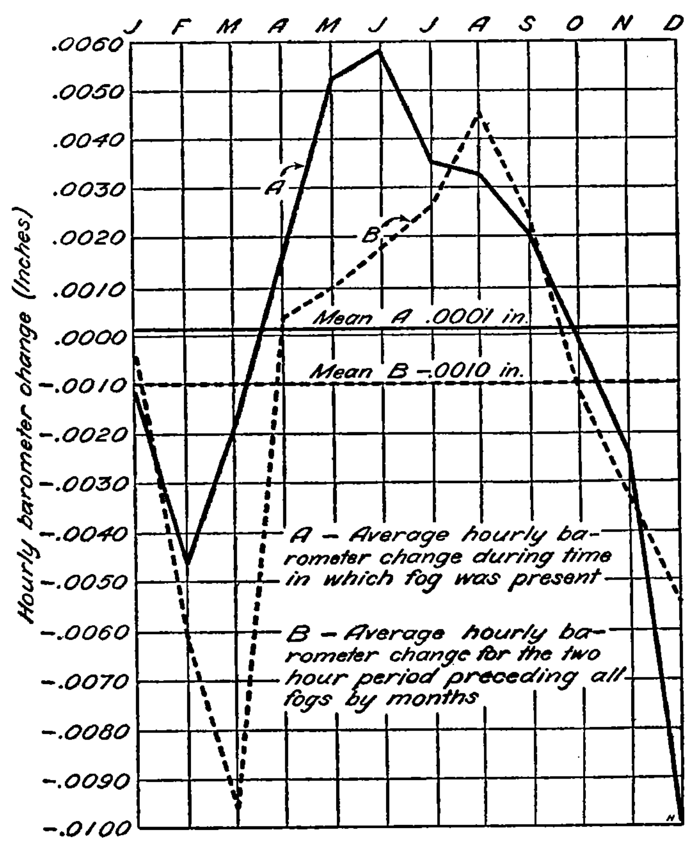

FIGURE 3.

is favorable to fog formation and the barometer obviously falls as the HIGH eventually recedes northeastward.

Second, moisture-laden air from some souther direction frequently blows in. Due to the fact that air around the surface of the ground in this time of year is relatively cold a layer of this air, which has been blown in, is cooled below its dew point and thereby results in condensation in the form of fog.

In other words, the condition probably exists because, in one case, of the receding of a HIGH accompanied by predominating northeast winds, and in the other case by the approach of a LOW with resulting southerly winds.

The conclusion arrived at as a result of the barometer study is that, in general, the barometer tendency during and immediately preceding fog formation is to fall in months of high pressure and to rise in months of low pressure.

TABLE 1.—*Wind direction and velocity*

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
A									
January	6	6	4	0	2	18	8	3	0
February	5	5	2	1	2	14	2	1	0
March	5	4	1	3	3	3	1	1	0
April	7	9	0	5	2	2	1	0	0
May	1	10	2	0	4	5	2	3	0
June	3	6	3	1	3	2	3	3	0
July	2	3	4	1	4	4	3	2	0
August	8	3	1	1	4	7	3	4	1
September	1	8	1	1	9	5	3	0	0
October	5	11	0	0	4	6	1	1	1
November	4	18	2	1	5	10	2	1	0
December	4	7	3	2	5	14	13	1	0
Total	51	90	23	16	47	90	42	20	2
B									
January	7	7	2	1	10	11	6	3	0
February	0	8	2	1	5	12	4	0	0
March	3	7	3	1	3	4	0	0	0
April	3	11	3	5	1	1	1	1	0
May	3	8	5	1	3	7	0	0	0
June	4	5	4	1	4	5	1	0	0
July	2	1	7	1	4	4	3	1	0
August	5	5	0	2	4	7	6	3	0
September	2	7	1	1	10	5	1	1	0
October	1	14	2	1	2	5	2	1	1
November	3	24	0	3	5	7	1	0	0
December	4	15	2	1	7	16	4	0	0
Total	37	112	31	19	58	84	29	10	1
A	13	24	6	4	12	24	11	5	1
B	10	29	8	5	15	22	8	3	0

(A) shows the prevailing wind direction during each of the 381 fogs. (B) shows the same thing for the 2-hour period preceding each case.

The lower lines contain the percentages of wind directions from the various directions during fogs (A) and for the 2-hours preceding fogs (B).

Table 1 shows the prevailing wind for all fogs during the period to be northeast and southwest (90 cases of each), and the prevailing direction for the 2 hours preceding fog formation to be northeast.

TABLE 2

	Average hourly wind velocity	Average hourly wind velocity during fogs	Average hourly wind velocity for the 2 hours preceding fogs
January	7.6	5.2	5.8
February	7.6	5.8	5.8
March	9.8	7.5	7.0
April	8.4	7.5	7.0
May	7.5	5.2	6.0
June	6.5	4.8	5.0
July	6.2	3.8	3.0
August	5.6	4.0	3.8
September	6.4	4.8	4.2
October	6.5	5.0	5.0
November	6.8	7.0	6.5
December	7.0	5.2	6.2
Mean	7.2	5.5	5.4

A vast majority of the fogs occurring in the months November, December, January, and February are unquestionably frontal. In November, A and B, particularly A (table 1) show a preponderance of northeast winds. Thus November seems to be the typical month in which fog forms largely from colder air being blown into a warmer area. During and immediately preceding fogs in December, January, and February southwest winds predominate. Thus it seems that in these months fogs form mostly due to relatively warm southwest winds blowing into a colder area, with a resulting temperature drop sufficient to cause the dew point to be reached.

No discussion will be made of table 1 in regard to the months in which radiational fogs chiefly occur, because this type of fog cannot occur unless there is very little air motion.

The abnormal month in table 2 is November. Every other month conforms to the accepted principle that fog usually forms with a lighter-than-normal wind velocity. However, during and just prior to the November cases this condition apparently did not exist. It is believed this exception was due to the fact that a great majority of the November fogs are accompanied by northeast winds, which usually are of greater velocity than the winds that generally accompany fogs.

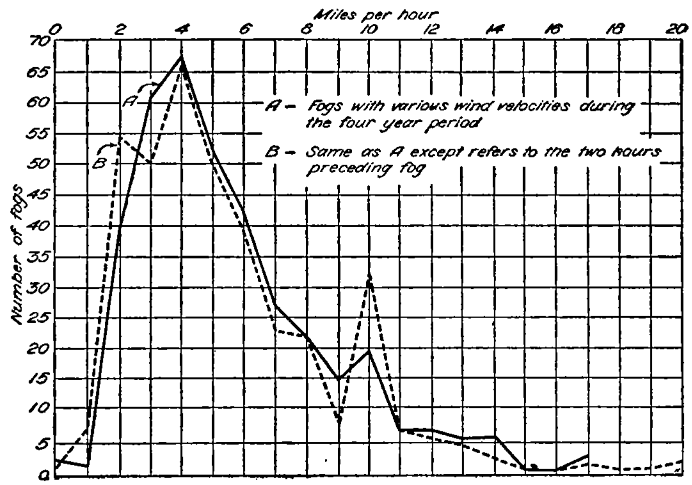

FIGURE 4.

Figure 4 shows that 4 miles an hour is the wind velocity at which fog is most likely to occur. This graph also substantiates the opinion that it is almost impossible for fog to form without some air motion A and B show an almost entire absence of cases occurring with a velocity of less than 2 miles an hour. The fact that fogs usually occur with light winds is, of course, too well known to require any discussion. Line A (fig. 4) further shows that there were three cases with an average hourly velocity of 17 miles an hour. Two of these fogs lasted only 1 hour each. However, on November 4, 1930, fog prevailed for 5 hours with this high velocity and was accompanied by a north wind.

TABLE 3.—*Temperature*

	(A)	(B)		(A)	(B)
January	−0.35°	−0.33°	August	−0.25°	0.50°
February	−0.60°	0.00°	September	−0.15°	0.00°
March	−0.50°	−0.67°	October	−0.22°	−0.60°
April	−0.75°	0.50°	November	−0.28°	0.00°
May	0.05°	0.00°	December	−0.25°	−0.33°
June	0.30°	0.28°			
July	0.08°	0.00°	Mean	−0.24°	−0.05°

Column A (table 3) contains the average monthly temperature change between 5 a.m. and 6 a.m. Column B contains the average monthly temperature change between these hours when fog is present. Lack of sufficient cases is very likely responsible for the months under B which seem to be abnormal. However the means verify the generally accepted theory that temperature during fog tends to change relatively little. 5 a.m. to 6 a.m. was taken as the hour to be compared because of the "clustering" of fogs around 6 a.m. It is believed that the conditions which actually exist are represented by July. A for this month shows a rise of 0.08°, which is probably the result of "insolation"; while B for this month shows no change.

During the 2-hour period preceding fog the average velocity upon 2 occasions was 20 miles an hour.

Sixty-nine percent of the cases occurred with a wind velocity of 2–6 miles/hour; and 68 percent of the time in the 2-hour period preceding all fogs the wind velocity also was 2–6 miles/hour.

HOURS OF OCCURRENCE

The mid-point of each of the 381 cases is shown on figure 5. It was found that more fogs are centered around 6 a.m. than any other hour, and that fogs to a very marked extent, tend to "cluster" around the hours 3 a.m.–6 a.m. It is significant that nearly ½ the cases fell within these limits. There is a very apparent increase for fog-centers between the hours 2 a.m. and 3 a.m., and an almost as noticeable drop in the cases of 6 a.m. and 7 a.m. Thus these data bring out very clearly that the above-mentioned hours are the ones in which fogs really tend to "cluster." This condition is very likely, at least to a large extent, owing to the fact that practically all radiational fogs are centered around these hours.

It is noted that there is an almost total absence of fogs between noon and 10 p.m. It was of course known that only relatively few fogs were centered around these hours, but the actual small number was somewhat unexpected. The vast majority of the fogs centered around

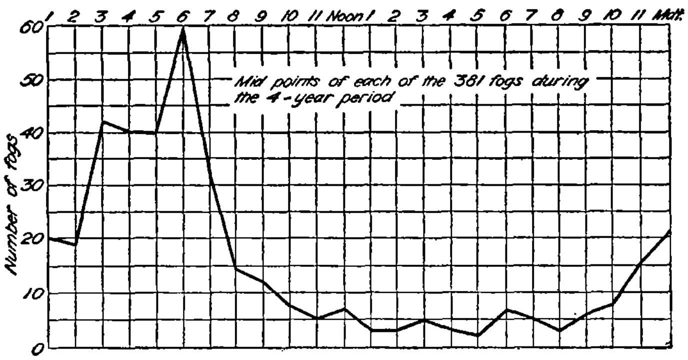

FIGURE 5.

these hours are unquestionably frontal, and occur almost entirely during the months in which this kind of fog predominates.

DUST STORM OF APRIL 12, 1934, BATON ROUGE, LA.

By RICHARD JOEL RUSSELL and R. DANA RUSSELL

[Louisiana State University]

Residents of the "Deep South" seldom experience visibility reduced to 3 or 4 (International Scale) as the result of atmospheric dust, hence speculation was rife on April 12, 1934, when this phenomenon occurred. Throughout the day in Baton Rouge, La., though the sky was cloudless, shadows were barely discernible. Sunshine duration, as recorded on a Friez instrument, was limited to 5 hours, 12 minutes, during the middle of the day, whereas a few days earlier in the season it had amounted to as much as 10 hours, 15 minutes. Notably reduced visibilities were reported at least as far east as Atlanta, Ga. An aviator flying at an elevation of 1,000 feet in central Louisiana found visibility so poor that he ascended to 6,000 feet to avoid dust and, later, had considerable difficulty in landing at Houston, Tex. Though the intensity of the dust storm was much greater in the Plains States, to the northwest, its occurrence was of unusual interest in the Southeast as having been possibly the severest on record.

Weather conditions.—Significant changes in weather conditions, as observed at Louisiana State University, for April 11, 12, and 13 are tabulated below.

Time	Wind		Relative			Notes
	Direction	Velocity	Temperature	Humidity	Pressure	
Apr. 11		*Miles per hour*	*°F.*	*Percent*	*Inches*	
3:00 p.m.	SE	8	83.7	>90	29.67	
4:15 p.m.	SW	4	81			
6:20 p.m.	S	6	77			
7:00 p.m.	SE	6	75.5	77	29.830	
8:13 p.m.	E	7	73			
8:47 p.m.	N	25	68			0.15 inch rain in 3 minutes; very severe electrical storm.
	Veer					
9:04 p.m.	SW	3	69			0.04 inch rain in 15 minutes, to end.
9:32 p.m.	W	3	69			
11:15 p.m.	N	5	69	67		
Apr. 12						
7:00 a.m.	N	11	57.0	43	29.970	Dust storm lasting through day.
2:00 p.m.	NW	10	68.4	<40		
7:00 p.m.	NW	5	60.5	46	29.900	
Apr. 13						
7:00 a.m.	NW	4	48.8	72	29.930	

During the afternoon of April 11, Baton Rouge was covered by warm, moist, *southerly* air. Rather sultry conditions were ameliorated to some extent by increased wind velocity and a sharp shower accompanying a severe electrical storm later in the evening. The temperature, however, rose slightly after the storm and remained constant until almost midnight, when, with wind from the north, it dropped gradually to a minimum of 56° F. at 6 a.m., on the 12th. Hygrograph and thermograph curves were strikingly parallel during the night, both rising slightly between the cessation of rain and 11:15 p.m. The arrival of a *cold front* was accompanied by a long period of backing wind, a pronounced squall and thunder storm, and, finally, a long period of veering wind. The relative humidity remained decidedly low throughout April 12, when *polar* air conditions were thoroughly established.

Rain had fallen in Baton Rouge on 5 days of the week preceding April 11, with an accumulated total of 1.8 inches. On April 10 none fell but the soil remained comparatively moist from a fall of 0.48 inch on the 9th. It therefore seems evident that very little dust of local origin could have entered the air by the 12th. The showers during the evening of the 11th should have prevented any raising of dust by accompanying squall-winds. The sky was exceptionally clear soon after the electrical storm. At sunrise, somewhat more than 6 hours after northerly winds had become established, the entire sky was overcast by dust and horizontal visibilities on ground level were reduced to "Fair" or "Indifferent." Though there were no very striking differences in visibility during the day, it was the local consensus of opinion that they were most reduced in the late afternoon and were rapidly improving toward sunset. Prominent objects were unidentifiable at a distance of 1 mile when visibility was at a minimum.

Description of dust.—Dust was collected at a height of approximately 50 feet above the ground on a vertically suspended damp cloth about 1 yard square. At frequent intervals, between 2 and 4 p.m., the cloth was rinsed in water, which was subsequently filtered in order that the